

**WHAT IS CLAIMED IS:**

- 1           1.       A gain medium comprising:  
2           a concentrated solid including a plurality of semiconductor nanocrystals, wherein the  
3           concentrated solid is substantially free of defects.
- 1           2.       The gain medium of claim 1, wherein the solid includes greater than 0.2% by  
2           volume of semiconductor nanocrystals.
- 1           3.       The gain medium of claim 1, wherein the solid includes greater than 10% by  
2           volume of semiconductor nanocrystals.
- 1           4.       The gain medium of claim 1, wherein each of the plurality of semiconductor  
2           nanocrystals includes a same or different first semiconductor material selected from the  
3           group consisting of a Group II-VI compound, a Group II-V compound, a Group III-VI  
4           compound, a Group III-V compound, a Group IV-VI compound, a Group I-III-VI compound,  
5           a Group II-IV-VI compound, and a Group II-IV-V compound.
- 1           5.       The gain medium of claim 4, wherein each first semiconductor material is  
2           selected from the group consisting of ZnS, ZnSe, ZnTe, CdS, CdSe, CdTe, HgS, HgSe,  
3           HgTe, AlN, AlP, AlAs, AlSb, GaN, GaP, GaAs, GaSb, GaSe, InN, InP, InAs, InSb, TiN,  
4           TiP, TiAs, TiSb, PbS, PbSe, PbTe, and mixtures thereof.
- 1           6.       The gain medium of claim 4, wherein each first semiconductor material is  
2           overcoated with a second semiconductor material.
- 1           7.       The gain medium of claim 6, wherein second semiconductor material is ZnO,  
2           ZnS, ZnSe, ZnTe, CdO, CdS, CdSe, CdTe, MgO, MgS, MgSe, MgTe, HgO, HgS, HgSe,  
3           HgTe, AlN, AlP, AlAs, AlSb, GaN, GaP, GaAs, GaSb, InN, InP, InAs, InSb, TiN, TiP, TiAs,  
4           TiSb, TiSb, PbS, PbSe, PbTe, or mixtures thereof.

1           8.       The gain medium of claim 6, wherein each first semiconductor material has a  
2 first band gap and each second semiconductor material has a second band gap that is larger  
3 than the first band gap.

1           9.       The gain medium of claim 1, wherein each nanocrystal has a diameter of less  
2 than about 10 nanometers.

1           10.      The gain medium of claim 1, wherein the plurality of nanocrystals have a  
2 monodisperse distribution of sizes.

1           11.      The gain medium of claim 1, wherein the plurality of nanocrystals include a  
2 plurality of monodisperse distribution of sizes.

1           12.      The gain medium of claim 1, wherein the concentrated solid of nanocrystals is  
2 disposed on a substrate.

1           13.      The gain medium of claim 12, wherein the substrate is glass and the  
2 concentrated solid of nanocrystals has a thickness greater than about 0.2 microns.

1           14.      A gain medium comprising:  
2 a concentrated solid including a plurality of semiconductor nanocrystals, wherein the  
3 concentrated solid is capable of providing gain to an optical signal greater than about  
4  $25 \text{ (cm}^{-1}\text{)}$  and the maximum gain occurs at an energy equal to or less than the maximum band  
5 gap emission of the nanocrystals.

1           15.      The gain medium of claim 14, wherein the concentrated solid is capable of  
2 providing gain to an optical signal greater than about  $50 \text{ (cm}^{-1}\text{)}$ .

1           16.      The gain medium of claim 14, wherein each of the plurality of semiconductor  
2 nanocrystals includes a same or different first semiconductor material selected from the  
3 group consisting of a Group II-VI compound, a Group II-V compound, a Group III-VI

4 compound, a Group III-V compound, a Group IV-VI compound, a Group I-III-VI compound,  
5 a Group II-IV-VI compound, and a Group II-IV-V compound.

1 17. The gain medium of claim 16, wherein each first semiconductor material is  
2 selected from the group consisting of ZnS, ZnSe, ZnTe, CdS, CdSe, CdTe, HgS, HgSe,  
3 HgTe, AlN, AlP, AlAs, AlSb, GaN, GaP, GaAs, GaSb, GaSe, InN, InP, InAs, InSb, TiN,  
4 TiP, TiAs, TiSb, PbS, PbSe, PbTe, and mixtures thereof.

1 18. The gain medium of claim 16, wherein each first semiconductor material is  
2 overcoated with a second semiconductor material.

1 19. The gain medium of claim 18, wherein second semiconductor material is  
2 ZnO, ZnS, ZnSe, ZnTe, CdO, CdS, CdSe, CdTe, MgO, MgS, MgSe, MgTe, HgO, HgS,  
3 HgSe, HgTe, AlN, AlP, AlAs, AlSb, GaN, GaP, GaAs, GaSb, InN, InP, InAs, InSb, TiN,  
4 TiP, TiAs, TiSb, PbS, PbSe, PbTe, or mixtures thereof.

1 20. The gain medium of claim 18, wherein each first semiconductor material has a  
2 first band gap and each second semiconductor material has a second band gap that is larger  
3 than the first band gap.

1 21. The gain medium of claim 14, wherein each nanocrystal has a diameter of less  
2 than about 10 nanometers.

1 22. The gain medium of claim 14, wherein the plurality of nanocrystals have a  
2 monodisperse distribution of sizes.

1 23. A gain medium comprising:  
2 a concentrated solid including a plurality of semiconductor nanocrystals, wherein a  
3 concentrated solid is capable of providing gain at energies in which a concentrated solid is  
4 substantially free of absorption.

1 24. The gain medium of claim 23, wherein each of the plurality of semiconductor  
2 nanocrystals includes a same or different first semiconductor material selected from the

3 group consisting of a Group II-VI compound, a Group II-V compound, a Group III-VI  
4 compound, a Group III-V compound, a Group IV-VI compound, a Group I-III-VI compound,  
5 a Group II-IV-VI compound, and a Group II-IV-V compound.

1 25. The gain medium of claim 24, wherein each first semiconductor material is  
2 selected from the group consisting of ZnS, ZnSe, ZnTe, CdS, CdSe, CdTe, HgS, HgSe,  
3 HgTe, AlN, AlP, AlAs, AlSb, GaN, GaP, GaAs, GaSb, GaSe, InN, InP, InAs, InSb, TiN,  
4 TiP, TiAs, TiSb, PbS, PbSe, PbTe, and mixtures thereof.

1 26. The gain medium of claim 24, wherein each first semiconductor material is  
2 overcoated with a second semiconductor material.

1 27. The gain medium of claim 26, wherein each first semiconductor material has a  
2 first band gap and each second semiconductor material has a second band gap that is larger  
3 than the first band gap.

1 28. The gain medium of claim 23, each nanocrystal has a diameter of less than  
2 about 10 nanometers.

1 29. The gain medium of claim 23, wherein the plurality of nanocrystals have a  
2 monodisperse distribution of sizes.

1 30. A laser comprising:  
2 an optical gain medium comprising a concentrated solid including a plurality of  
3 semiconductor nanocrystals; and  
4 a cavity arranged relative to the optical gain medium to provide feedback.

1 31. The laser of claim 30, wherein the concentrated solid is substantially free of  
2 defects.

1 32. The laser of claim 30, further comprising an excitation source.

1 33. The laser of claim 32, wherein the excitation source is an optical source.

1           34.     The laser of claim 33, wherein each of the plurality of semiconductor  
2 nanocrystals includes a same or different first semiconductor material selected from the  
3 group consisting of a Group II-VI compound, a Group II-V compound, a Group III-VI  
4 compound, a Group III-V compound, a Group IV-VI compound, a Group I-III-VI compound,  
5 a Group II-IV-VI compound, and a Group II-IV-V compound.

1           35.     The laser of claim 34, wherein each first semiconductor material is overcoated  
2 with a second semiconductor material.

1           36.     The laser of claim 35, wherein each first semiconductor material has a first  
2 band gap and each second semiconductor material has a second band gap that is larger than  
3 the first band gap.

1           37.     The laser of claim 30, wherein the plurality of nanocrystals have a  
2 monodisperse distribution of sizes.

1           38.     A laser comprising:  
2 an optical gain medium comprising a concentrated solid including a plurality of  
3 semiconductor nanocrystals; and  
4 a microcavity arranged relative to the optical gain medium to provide feedback.

1           39.     The laser of claim 38, wherein each of the plurality of semiconductor  
2 nanocrystals includes a same or different first semiconductor material selected from the  
3 group consisting of a Group II-VI compound, a Group II-V compound, a Group III-VI  
4 compound, a Group III-V compound, a Group IV-VI compound, a Group I-III-VI compound,  
5 a Group II-IV-VI compound, and a Group II-IV-V compound.

1           40.     The laser of claim 38, wherein each first semiconductor material is overcoated  
2 with a second semiconductor material.

1           41.     The laser of claim 40, wherein each first semiconductor material has a first  
2     band gap and each second semiconductor material has a second band gap that is larger than  
3     the first band gap.

1           42.     The laser of claim 38, wherein the plurality of nanocrystals have a  
2     monodisperse distribution of sizes.

1           43.     A laser comprising:  
2             an optical gain medium comprising a concentrated solid including a plurality of  
3     semiconductor nanocrystals; and  
4             a cavity arranged relative to the optical gain media to provide feedback, wherein the  
5     concentrated solid provides gain to an optical signal at an energy equal to or less than the  
6     maximum band gap emission of the nanocrystals.

1           44.     The laser of claim 43, wherein each of the plurality of semiconductor  
2     nanocrystals includes a same or different first semiconductor material selected from the  
3     group consisting of a Group II-VI compound, a Group II-V compound, a Group III-VI  
4     compound, a Group III-V compound, a Group IV-VI compound, a Group I-III-VI compound,  
5     a Group II-IV-VI compound, and a Group II-IV-V compound.

1           45.     The laser of claim 43, wherein each first semiconductor material is overcoated  
2     with a second semiconductor material.

1           46.     The laser of claim 45, wherein each first semiconductor material has a first  
2     band gap and each second semiconductor material has a second band gap that is larger than  
3     the first band gap.

1           47.     The laser of claim 43, wherein the plurality of nanocrystals have a  
2     monodisperse distribution of sizes.

1           48.     A gain medium comprising:  
2             a concentrated solid including a plurality of semiconductor nanocrystals, wherein the

3 concentrated solid is substantially free of defects, provides gain to an optical signal at an  
4 energy equal to or less than the maximum band gap emission of the nanocrystals, and is  
5 capable of providing gain at energies in which a concentrated solid is substantially free of  
6 absorption.

1 49. A method of amplifying an optical signal comprising:  
2 directing an optical beam into a gain medium including a concentrated solid including  
3 a plurality of semiconductor nanocrystals, wherein the concentrate solid is substantially free  
4 of defects and provides gain to the optical signal at an energy equal to or less than the  
5 maximum band gap emission of the nanocrystals.

1 50. The method of claim 49, wherein each of the plurality of semiconductor  
2 nanocrystals includes a same or different first semiconductor material selected from the  
3 group consisting of a Group II-VI compound, a Group II-V compound, a Group III-VI  
4 compound, a Group III-V compound, a Group IV-VI compound, a Group I-III-VI compound,  
5 a Group II-IV-VI compound, and a Group II-IV-V compound.

1 51. The method of claim 49, wherein each first semiconductor material is  
2 overcoated with a second semiconductor material.

1 52. The method of claim 49, wherein each first semiconductor material has a first  
2 band gap and each second semiconductor material has a second band gap that is larger than  
3 the first band gap.

1 53. A method of forming a laser comprising:  
2 arranging a cavity relative to a gain medium to provide feedback to the optical gain  
3 medium, wherein the optical gain medium comprises a concentrated solid including a  
4 plurality of semiconductor nanocrystals.

1 54. The method of claim 53, wherein each of the plurality of semiconductor  
2 nanocrystals includes a same or different first semiconductor material selected from the  
3 group consisting of a Group II-VI compound, a Group II-V compound, a Group III-VI

4 compound, a Group III-V compound, a Group IV-VI compound, a Group I-III-VI compound,  
5 a Group II-IV-VI compound, and a Group II-IV-V compound.

1 55. The method of claim 53, wherein each first semiconductor material is  
2 overcoated with a second semiconductor material.

1 56. The method of claim 53, wherein each first semiconductor material has a first  
2 band gap and each second semiconductor material has a second band gap that is larger than  
3 the first band gap.